UNITED NATIONS

A

General Assembly

Distr.
GENERAL

A/AC.105/523/Add.1
10 February 1993

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

INTERNATIONAL COOPERATION IN THE PEACEFUL USES OF OUTER SPACE - ACTIVITIES OF MEMBER STATES

Note by the Secretariat

Addendum

The present document contains information provided in replies received from Member States up to 9 February 1993.

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FINLAND

[Original: English]

Finnish space activities are concentrated in three programme areas: space science, Earth observation and telecommunications. The main objectives are:

- To play an active role in advancing fundamental scientific knowledge;
- To develop Earth observation activities in nationally important areas, such as forestry, meteorology, mapping, sea, ice and snow;
- To develop technological capabilities in order to support the creation of the space industry.

The volume of Finnish space research and development activities in 1992 is about 100 million Finnish markkaa (equal to US$ 20 million).

International cooperation is an essential element of the Finnish space activities. Finland has been an Associate Member of the European Space Agency (ESA) since the beginning of 1987 and participates in the Agency's scientific, Earth observation and telecommunications programmes. The importance of cooperation within ESA's programmes has steadily grown and today over 50 per cent of Finnish research-and-development activities in this field are connected to ESA's space programmes and projects.

Finnish scientists have also take part in many other international space science missions. In particular, Finland actively participates in Soviet/Russian space missions, in Swedish scientific satellites projects and in some space missions of the United States National Aeronautics and Space Administration (NASA).

In the field of Earth observation, Finland participates in ESA's satellite development projects, but the main emphasis is to develop new applications for national user organizations. Although the specific needs of the developing countries are not taken into account, results of Earth observation projects can be exploited widely and they can also support the needs of the developing countries.

Finland participates in space programmes in order to obtain economic and social benefits. Finland has been an active user of space technology, which creates short-term benefits for the country. Finland uses meteorological satellites for observing the atmosphere and clouds, telecommunications satellites for international telephony and for television transmission as well as Earth observation satellites for environmental monitoring and for remote sensing of natural resources. Finland does not have its own satellites and therefore the owners of the exploited satellites are international user organizations, ESA and national space agencies.

The long-term benefits are important in particular in the field of new technologies and commercial opportunities.

The research and development of space technology is an important element of the Finnish space activities. Finnish industry and research institutes are active in this field, but no research on nuclear-powered satellites or space debris has been carried out.

MAURITIUS

[Original: English]

1. Much of the writing about humanity's future in space has been dominated by proposals for large-scale space operations that aim to bypass the Earth's resource limits, for example by importing energy and materials from space. But this is an unworkable attempt to escape from the problems of the Earth. Outer space can be valuable not as a source of energy or materials, but rather as a tool, both for learning more about our planet and for assisting problem solving here on Earth.

2. Developing countries should take an interest in the development and application of space technology and space sciences for the socio-economic benefit of the nation. This is particularly so in areas where satellite-based systems have an inherent edge over conventional ground-based systems. The areas cover telecommunications, radio and television broadcasting and remote sensing, the latter with its widespread application in agriculture, forestry, meteorology, Earth sciences and the like.

3. The involvement of industrial undertakings in the highly exacting and demanding tasks relating to all this activity will lead to the development of indigenous industrial infrastructure, capabilities and expertise in these fields.

4. Space stations will be ideal for making advanced studies in materials science and for making studies of manufacturing in the zero-gravity space environment; for making an inventory of the Earth's non-renewable and renewable resources and global environment studies. Space biologists can determine how to use the space environment to help advance medicine, agriculture and public health. Education should also greatly benefit from space stations.

5. Two space activities that could be the subject of international cooperation are described below. Both of the following activities describe the possible application of outer space to astronomical observations:

(a) A satellite system for antenna calibration;

(b) Aperture synthesis in space.

A. A satellite system for antenna calibration

The techniques of radio interferometry as applied to astronomy and astrometry have developed enormously in the past four decades, and the attainable resolution has advanced from degrees to milliarcseconds. This has happened in the higher-frequency end of the radio spectrum (at mm wavelengths). The quest for higher resolution at metre and decametre wavelengths has been hindered by the fact that the construction and maintenance of large arrays proved to be difficult. Advanced techniques of interferometry have been rendered less useful as the ionosphere introduces time-varying amplitude and phase variations over the antenna aperture.

Many of these shortcomings have been overcome in recent years by the use of advanced calibration techniques such as closure phase imaging and self-calibration. Unfortunately, most of these techniques have not yet been optimally used at the metre wavelengths as calibrator sources are not readily available. A satellite with a payload to emit in the required frequency ranges to calibrate the antennas will definitely attract the attention of astronomers all over the globe.

B. Aperture synthesis in space

Angular resolution obtainable at optical wavelengths is restricted to 1 arcsecond by the atmospheric turbulence. Thus a 4 m telescope with a theoretical image-forming capability of forming images as sharp as 25 milliarcseconds is no better than a 10-cm amateur astronomer's telescope in the presence of turbulent atmosphere.

Thus it is not inconceivable to set up optical arrays in space to obtain high dynamic range and high-resolution images free from the effects of the atmosphere. The Hubble Space Telescope is a step in this direction. A much higher-resolution synthesis array working on the principles of aperture synthesis extensively used in radio astronomy will allow a real scientific breakthrough. This will also, no doubt, attract the attention of the optical astronomers all over the globe.

PAKISTAN

[Original: English]

1. Introduction

1.1 The Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) is the national space agency responsible for the execution of space science and technology programmes in the country. The main objective of Pakistan's space programme is to promote the peaceful exploration and applications of space science and technology to bring about the socio-economic uplift of the country.

1.2 The principal goals of SUPARCO are:

- To promote the peaceful applications of space science and technology, particularly in the areas which are of direct concern to Pakistan;

- To liaise with national and international agencies and organizations in the matters connected with or related to space science and technology;

- To advise the Government of Pakistan on designing short- as well as long-term programmes of space science and technology and assist in devising policies with regard to issues arising out of developments in space science and technology on the international scene.

1.3 The main research-and-development projects being carried out in SUPARCO are: (i) development of necessary facilities for designing, assembly/fabrication of lightweight satellites for remote sensing, communications and scientific studies (in near Earth orbits); (ii) conduct of studies based on the application of satellite/aerial remote-sensing data for Earth resources and environmental survey; (iii) establishment of satellite ground stations for satellite communications; (iv) establishment of facilities for tracking of satellites/rockets; and (v) studies in the fields of the ionosphere, radio-wave propagation and atmospheric sciences using satellites, rockets and ground-based equipment.

2. Research and applications programmes

(a) Remote-sensing applications

2.1 The management of a nation's natural resources calls for a system to make surveys of resources such as air, water and the surface of the soil and subsoil. The system should survey and record changes in each of these types of resources, whether the changes are of natural or man-made origin. Remote-sensing satellites such as the United States Landsat and the French Spot satellite are used for topographic and geological mapping and mineral exploration. They provide useful data on agricultural resources which can be used for predicting harvests, evaluating forests and deserts, managing water resources and coastal regions, analysing environmental-impact studies and evaluating the damage caused by natural disasters.

2.2 SUPARCO had established in 1978 a full-fledged National Remote Sensing Applications Centre, called RESACENT, which is engaged in carrying out the studies based on the application of satellite remote-sensing data to various Earth resources and environmental problems covering a wide range of Earth sciences. As the national coordinator, SUPARCO acquires and archives satellite remote sensing (SRS) data of the country and disseminates these data to national user agencies on request. In addition to the main RESACENT Centre at Karachi, regional remote-sensing centres have been established in major

cities of Pakistan to provide users in different parts of the country with access to data and basic interpretation facilities.

Data interpretation facilities

2.3 RESACENT has adequate facilities for visual and digital analysis of remote-sensing data, including a well-equipped photographic laboratory. Digital processing facilities include a microprocessor-based digital image processing system, called EBBA II, a Micro-VAX II computer and a GPX II workstation. A Local Area Network (LAN) incorporating eight user terminals and a GPX II workstation was developed around the Micro-VAX II.

Satellite Ground Station

2.4 SUPARCO has been engaged in the application of satellite remote-sensing data, for a broad variety of applications, since the early 1970s. By the early 1980s it was felt that remote-sensing applications activity in Pakistan had expanded sufficiently to warrant the establishment of data acquisition facilities within the country for providing real time/near real time data to national user agencies. SUPARCO accordingly established a Satellite Ground Station at Islamabad for the acquisition of Landsat MSS and TM, Spot HRV multispectral (XS) and panchromatic (PAN) and NOAA AVHRR HRPT data, which became operational in 1989. The Satellite Ground Station continued to acquire and process the Landsat, SPOT, and NOAA data during the period under review.

2.5 Up to 30 June 1992, the Satellite Ground Station acquired approximately 13,480 Landsat TM scenes, 5,358 Landsat MSS scenes, 6,114 Spot XS scenes and 6,796 Spot PAN scenes, from which about 2,331 computer-compatible tapes (CCTs), 1,679 black-and-white and colour films and 1,876 black-and-white and colour prints at various scales were generated for various user agencies or for use within SUPARCO.

Application studies

2.6 Some of the important studies conducted during the period under review are:

- Study of biomass fuel energy resources based on satellite remote-sensing data;

- Assessment of biomass, water and natural resources in the Thar, Nara and Kohistan regions of the Thar Desert using SRS data;

- Identification and mapping of landforms and mangroves in the Indus delta;

- Mapping and monitoring of wetlands using satellite remote-sensing data;

- Area estimation of agricultural crops using satellite data;
- Urban growth monitoring using Spot PAN and XS data;
- Geological/geomorphological studies;
- Use of Landsat data in geological studies of the Bannu basin;
- Study of salt lakes and evaporite deposits;
- Land-use study of the Peshawar valley using Landsat TM data;
- Monitoring turbidity/siltation in Kalri Lake using satellite remote-sensing data;
- Mapping and monitoring of land accretion/erosion and sediment distribution;
- Study of the headlands of Ormara and Gwadar along the Makran coast;
- Land-use/forestry classification in hilly areas of the North-West Frontier Province;
- Mapping forests in the Margala hilly areas of Pakistan;
- Reconnaissance-level attributes of irrigation suitability land classification;
- Study on the feasibility of a canal from Guddu to Nagar Parkar.

(b) Satellite communications

2.7 The long-term development programme of SUPARCO includes the launching of a domestic communication satellite (Paksat) system for Pakistan. The communication satellite project includes the planning, design and implementation of the Paksat system, including technical and regulatory matters. In order to establish the necessary infrastructure for implementation of this project, several activities have been carried out, which include: (a) design and development of low-cost, low Earth orbit spacecraft (BADR-1); and (b) installation, operation and maintenance of ground receiving stations for tracking and reception of low Earth as well as geostationary satellites.

2.8 SUPARCO contributed a country paper on the allocation of different frequency bands for space radio communication services for the World Administrative Radio Conference (WARC-92) organized by the International Telecommunication Union (ITU) in Spain during February and March 1992.

Pakistan's second satellite, BADR-B

2.9 Based on the experience gained through BADR-1, further improvement in the design and functionality of another satellite, BADR-B being developed by SUPARCO as part of SUPARCO's satellite technology programme, has been taken in hand. The project envisages the development and fabrication of engineering and flight models of BADR-B, augmentation of test and integration facilities, procurement, installation and commissioning of a tracking, telemetry and telecommand (TTC) station, procurement of launch services and development of technical manpower. BADR-B is planned to be placed into a sun-synchronous circular orbit of approximately 700 km altitude in 1994 or later. BADR-B is shaped as a 450 x 450 x 450 mm cube, weighing around 50 kg, and will have an active life of about 2 to 3 years.

2.10 The bus, consisting of power, telemetry, telecommand and RF communications subsystems, will be based on an augmented version of BADR-1, while an on-board computer for central control and a gravity-gradient based system for attitude stabilization are being developed.

2.11 BADR-B will help in the further development of infrastructure for the design of low-cost small satellites and encourage the participation of the country's academic and scientific community in the applications of small satellites.

Direct broadcast satellite receiver (DBSR)

2.12 SUPARCO continued to manufacture S-band and C-band systems for direct reception of TV programmes using 2.5 m, 3.6 m and 6.1 m antennas.

Information retrieval system

2.13 The information retrieval system added new features and databases and continued to be available to support the research-and-development activities of SUPARCO.

Satellite tracking stations

2.14 The necessary software has been developed for the computerized control of the 3.6 m diameter antenna installed at the satellite tracking station at Karachi to revive the link with the BADR satellite. The system is expected to be operational shortly.

COSPAS-SARSAT programme

2.15 SUPARCO's satellite-aided search-and-rescue project has become operational with the commissioning of Pakistan's Local User Terminal (PALUT) and Mission Control Centre (PAMCC) at Lahore. The 406-MHz certification bench has also been installed and commissioned. The bench is capable of measuring parameters such as frequency, power, spectrum, message analysis and modulation of the 406-MHz beacon specifically designed for the COSPAS-SARSAT

satellite-aided SAR programme. The facility will also be used to measure these parameters for the 121.5-MHz and 242-MHz homing transmitters. PAMCC has started relaying alert-and-location data to the 12 countries within its service area through Civil Aviation Authority's AFTN, and 406-MHz interference monitoring is being carried out on a continuous basis.

(c) Space science and atmospheric research

2.16 The space science and neutral atmosphere research programme of SUPARCO includes satellite radiance studies, atmospheric pollution monitoring studies, satellite meteorology based on the use of NOAA APT images, the Tiros Operational Vertical Sounder (TOVS) receiving/processing system, use of satellites for the collection of meteorological, hydrological and environmental data from unattended remote data collection platforms, satellite geodesy and ionospheric research.

Atmospheric pollution monitoring studies

2.17 Atmospheric pollution studies involving the monitoring of various air pollutants continued to be carried out both at Karachi and at Lahore. Trace-element analysis of 30 aerosol samples collected at Pakistan Steel was being performed using an atomic absorption spectrophotometer. Measurements of environmental parameters were also carried out at the Karachi Electric Supply Corporation (KESC) power plant located at Bin Qasim, the newly established port at Karachi under an agreement with KESC.

Satellite meteorology

2.18 The APT Station set up at SPARCENT, Karachi in 1988 continued to provide, on routine basis, NOAA's thermal infrared images of Pakistan and surrounding areas and the temperature data at selected locations. These images are used to study weather patterns, with special reference to the summer monsoon, as well as other related environmental phenomena. A number of scientific studies have been carried out using APT data since the installation of the APT station, and it is inferred that these images are of utmost importance in aviation meteorology. Besides this, the cyclone study using APT data can also be carried out. An exclusive monitoring of the drastic cyclones which struck India and Bangladesh in 1990 and 1991 respectively were made by observing the pictorial APT data. In another study, the APT data were used in the determination of sea surface temperature of the exclusive economic zone of Pakistan.

Tiros Operational Vertical Sounder Receiving/Processing System

2.19 A ground receiving station for acquisition and processing of TOVS data from the NOAA series of satellites is expected to be installed in late 1992. The data will be processed to determine atmospheric vertical temperature and water-vapour profiles from the surface up to the stratosphere.

ARGOS (Satellite-based environmental data collection network) project

2.20 Environmental data from the ARGOS data collection platforms of remote sites in Pakistan were regularly being supplied to various user agencies.

(d) Ionospheric and geomagnetic research

2.21 SUPARCO has been involved in ionospheric research and related radio-wave propagation studies for about two decades now, and has accumulated a vast amount of data about ionospheric conditions in Pakistan. Three vertical ionospheric sounders are currently being operated, one each at Karachi, Islamabad and Multan, which provide round-the-clock data on a variety of ionospheric parameters. The sounder at Karachi is of the digital type (Digisonde DGS-256), while the two sounders at Multan and Islamabad are of the analog type (PIR-9 and PIR-9B). Pakistan's second digital sounder, Digisonde DGS-256, is planned to be installed at Islamabad to replace the existing analog sounder. Bulletins containing predictions for maximum usable frequency and optimum traffic frequency and geomagnetic data are regularly issued to various national user agencies.

2.22 An automatic magnetic observatory system (AMOS-III) is also in operation at Karachi for measuring and recording geomagnetic data which are used in various related studies.

3. Training courses/seminars/workshops/conferences

Local/foreign training programme/seminars/workshops sponsored/co-sponsored by SUPARCO

3.1 In-house orientation courses covering a wide range of subjects related to space science and technology for different groups of newly recruited scientists and engineers are conducted by SUPARCO. The following regional seminar/training courses were organized by SUPARCO during the period from July 1991 to June 1992:

- SUPARCO - Economic and Social Commission for Asia and the Pacific (ESCAP)/United Nations Development Programme (UNDP) Regional Seminar on the Applications of Remote Sensing Techniques to Land-use Planning and Environmental Surveying, held at Karachi from 21 to 27 October 1991. The Seminar was attended by 56 participants and observers from 16 countries and international agencies. Besides SUPARCO, 14 other organizations from Pakistan were represented at the Seminar. A total of 33 presentations, including 10 from SUPARCO, were made on a wide range of topics relating to the theme of the Seminar;

- A two-week Training Course on Environmental Pollution Monitoring with Special Reference to Characterization of Atmospheric Aerosols, Development of Techniques and Methodologies to Assess the Strength

and Adverse Impact of Pollutants, in collaboration with UNDP/NTP, Islamabad, from 8 to 20 February 1992.

Foreign training programme

3.2 Three SUPARCO scientists and engineers were sent abroad during the period under review for higher studies leading to the M.S. or Ph.D. degree in various disciplines of space science and technology. At present, 35 scientists and engineers are studying abroad.

International conferences/meetings attended by SUPARCO scientists and engineers

3.3 SUPARCO scientists/engineers attended the following conferences/meetings during 1991-1992:

- GOSS 6 meeting, organized by SPOT IMAGE in Toulouse, France in August 1991;

- Annual meeting of the Directors of the National Remote Sensing Centres/Programmes of the ESCAP Region and the associated session of the Intergovernmental Consultative Committee (ICC) of RRSP, held at Hyderabad, India, from 9 to 15 September 1991;

- COSPAS-SARSAT Fifth Joint Committee (JC-5) meeting held at Bangalore, India, from 9 to 18 September 1991;

- International Workshop on Wetland Use and Flood Damage Evaluation System, held at Changsha, China, from 17 to 20 September 1991;

- United Nations/International Astronautical Federation (IAF)/Canada Workshop on Space Technologies for Development, held at Montreal, Canada, from 2 to 5 October 1991;

- Forty-second International Astronautical Congress of IAF held at Montreal, Canada, from 6 to 12 October 1991;

- Third United Nations International Training Course on Remote Sensing Applications to Geological Science held at Postdam, Germany, from 7 to 25 October 1991;

- Fifth meeting of the Organization of the Islamic Conference (OIC) Ministerial Standing Committee on Scientific and Technological Cooperation (COMSTECH), held at Islamabad from 11 to 13 November 1991;

- First Policy-level Awareness Workshop on Geographic Information Systems, organized by the International Centre for Integrated Mountain Development (ICIMOD) at Kathmandu, Nepal, on 14 and 15 November 1991;

- Course on Conservation and Management of Wetlands and Waterfowl, organized by the Asian Wetland Bureau, Malaysia, from 1 to 10 December 1991;

- Seventh session of the COSPAS-SARSAT Council, held in London, in December 1991;

- Second session of the Group of Governmental Experts to carry out a study on the Application of Confidence-Building Measures in Outer Space, New York, from 23 to 27 March 1992;

- European Conference on International Space Year, held at Munich, Germany, from 30 March to 4 April 1992;

- ERS-1 Radar Applications Course organized by the European Space Agency (ESA) at Frascati, Italy, from 22 April to 8 May 1992;

- Thirty-fifth session of the United Nations Committee on the Peaceful Uses of Outer Space, held at United Nations Headquarters, New York, from 15 to 26 June 1992.

University collaboration

3.4 Teaching support was provided to the University of Karachi and the University of the Punjab as in the previous years for M.Sc. (physics) and B.Sc. classes (space science) respectively. SUPARCO scientists also gave lectures on remote sensing to Master's degree students at the departments of geography and geology and environmental and management science of the universities of Karachi and Peshawar.

4. International Space Year

4.1 Increasing awareness throughout the world about the changes in our environment led to the proclamation of 1992 as International Space Year (ISY). This has resulted in the creation of Space Agency Forum on International Space Year (SAFISY), which has, at present, 28 members and 8 affiliates. SUPARCO is also a member of SAFISY. The ISY initiative has also been endorsed by the General Assembly of the United Nations. Accordingly, SUPARCO has been working on a comprehensive programme of celebrating ISY 1992. SUPARCO-ISY activities have included: TV/radio panel discussions/talks; topical seminars; publications of articles; issuance of commemorative stamp, etc.

4.2 Progress made so far in this regard is as follows:

(a) ISY-related scientific projects undertaken by SUPARCO:

- Pakistan as seen from Space - this project is aimed at producing a colour mosaic of Pakistan based on mosaicking of Landsat TM prints at a 1:1,000,000 scale. The annotated mosaic will provide a synoptic view of the entire country showing major landcover/landuse, hydrologic, geologic and geomorphic features (led by Pakistan's space agency, SUPARCO);

- Forest cover mapping - this project seeks to use space-borne observations in detection and mapping of the forest cover of the entire country, employing a Landsat-TM colour mosaic. The end-product would be used by the forest departments of the country (led by SUPARCO);

- Satellite image maps of major cities - the project is aimed at using satellite data in mapping urban features, urban growth and other cultural features of most of the major cities of the country. The end-products would be provided to educational institutions and agencies involved in monitoring urban growth, as well as to other related departments (led by SUPARCO);

- Deforestation/forest change detection - the project is aimed at monitoring the forest cover changes over a period of 14 years in the forested areas of the northern hills surrounding Pakistan's capital Islamabad, which are suffering degradation due to stone quarrying and related industrial activities (led by SUPARCO);

- Monitoring vegetal cover and crop growth using NOAA AVHRR vegetation indexing - in order to improve the use of NOAA HRPT data in inventorying vegetal cover and crop growth of the entire country over a period of three years, SUPARCO scientists are using temporal Normalized Difference Vegetation Index (NDVI) values derived from NOAA data (led by SUPARCO);

- Estimation of extent of snow cover - the Landsat TM images are being used in forecasting snowmelt-induced river run-off during the melting season from April onwards, corresponding to the driest part of the summer which is critical for optimal operation of Pakistan's complex irrigation system, comprising dams, barrages, hydro-electric plants, canals, etc.;

- Sea surface temperature variability - in order to improve the ocean temperature data, essential for atmospheric/ocean circulation models and prediction of adverse weather phenomena, SUPARCO scientists are using NOAA APT data of the exclusive economic zone of the country in estimating sea surface temperature variability during the pre-monsoon period (led by SUPARCO);

(b) Public education and awareness:

Exhibitions/fairs

SUPARCO has so far participated in the following national/international exhibition/fairs in connection with ISY:

- Science and technology exhibition on the occasion of the twenty-sixth annual National Science Conference, held at Bahawalpur, Pakistan in April 1992;

- International Space Year Activities Awareness Fair organized by the American Institute of Aeronautics and Astronautics (AIAA) at Houston, Texas, United States, in July 1992;

- Exhibition organized by the Geocarto International Centre at the Hong Kong Book Fair as part of ISY celebrations in July 1992;

- Space exhibition jointly organized by SUPARCO and the Amateur Astronautical Society of Pakistan (AMASTROPAK) at Karachi in August 1992;

- National science and technology fair 1992, held at Islamabad, Pakistan, in September 1992;

Radio/TV programmes/panel discussion

- SUPARCO, in collaboration with the Ministry of Information and Broadcasting, contributed to the preparation of a United Nations video on the applications of satellites for communication, broadcasting, remote sensing, space science and search and rescue;

- A documentary giving information about various activities of SUPARCO in the wake of ISY is being prepared;

- A series of 13 radio talks was delivered by the senior scientists of SUPARCO in special national programmes elaborating the significance of ISY and SUPARCO's role in its celebrations. Another such radio programme was broadcast by British Broadcasting Corporation (BBC) based upon the interview of the Chairman of SUPARCO;

- Two news reports on remote sensing and the COSPAS-SARSAT programme were telecast by the Pakistan Television Corporation, while another news report was telecast by Cable News Network (CNN) in a special television programme;

- A panel discussion on Earth Summit-1992 was organized by the Pakistan daily Urdu newspaper Jang. The participants included national experts on environment and members of the Jang panel. The full text of the discussion was published in the 5 June 1992 issue of the Newspaper;

Conferences/symposia/courses/workshops

- A short course on satellite-aided search and rescue operations was organized jointly by SUPARCO and the Inter-Islamic Network on Space Sciences and Technology (ISNET) from 19 to 23 July 1992 at Lahore, Pakistan, as part of ISY 1992 activities;

- The Chairman of SUPARCO participated as a panelist on Regional Panel on Asia in the Conference on Satellite Remote Sensing for Resource Management, Environmental Assessment, and Global Change Studies: Needs and Applications of Developing Countries, organized by the United Nations Office for Outer Space Affairs and the Government of the United States of America (NASA, NOAA, USGS and the Consortium for International Earth Science Information Network (CIESIN)) at Boulder, Colorado, United States, from 17 to 20 August 1992. He also presented a paper entitled "Knowledge Intensification - Needs of Developing Countries in Applications of Remote Sensing Technology";

- SUPARCO's scientists participated in the Wrold Space Congress and presented the following research papers at the COSPAR plenary meetings:

  - "Space Technology in the Mapping of Desertification in Pakistan";

  - "Pre-monsoon Sea Surface Temperature Variability over the Exclusive Economic Zone of Pakistan";

  - "Identifying Potential Solar Power Generation Sites using Satellite APT Images";

  - "Snowcover Estimation for River Run-off Forecasting using TM Data";

  - "Structural Evaluation for Mineral Exploration using Satellite Data";

  - "Forest Change Detection in the Margala Hills of Pakistan";

  - "Quasi-operational Use of the NOAA AVHRR Vegetation Index to Monitor Vegetal Cover and Crop Growth";

  - "Crop Monitoring and Estimation Using High-resolution Data";

Articles published

- "An Introduction to International Space Year 1992", published in the national press to introduce the significance of ISY 1992 to the national scientific community and the general public;

- "Building International Cooperation through ISY", published in the spring 1992 issue of International Technology and Society, journal of the Institute of Electrical and Electronics Engineers (IEEE), United States;

- "Activities Planned by Pakistan/SUPARCO during ISY 1992", published in the April 1992 issue of the ESCAP Remote Sensing Newsletter;

Commemorative stamps

- Two commemorative postage stamps were issued on 7 June 1992 on the occasions of ISY and the thirtieth anniversary of the launching of the first rocket in Pakistan by SUPARCO;

Public statements by national leaders

- The Prime Minister of Pakistan participated in the United Nations-sponsored Conference on Environment and Development (Earth Summit) held at Rio de Janeiro, Brazil, from 3 to 14 June 1992 and addressed the Conference in the capacity of Chairman of the Group of 77, presenting a four-point guideline for the Rio Declaration, as follows:

  - Collective cooperation to banish the inequality in the international economic order;

  - Linking of environment with development in order to eradicate poverty from the globe;

  - Enhancement of the consciousness of the masses on the need to reverse the deterioration of the Earth's environment;

  - Forging a partnership of trust and confidence to work together for reconstruction of the frayed relationship between the activities of mankind and the prerogatives of nature.

5. International collaboration

Foreign space agencies

5.1 Various foreign national and international space agencies have been cooperating with SUPARCO in the exchange of technical information, provision of data, consultancy services, training activities and collaborative studies in areas of mutual interest.

5.2 By virtue of an agreement signed between SUPARCO and the Earth Observation Satellite (EOSAT) Company of the United States, the latter has become SUPARCO's sales agent outside Pakistan for the sale of Landsat data (except for data pertaining to Pakistani territory), generated at the Satellite Ground Station, Islamabad.

5.3 The Chairman of SUPARCO and the Chinese Vice-Minister of the Aerospace Industry signed an Agreement in December 1991 at Beijing on the peaceful applications of space science and technology. The Agreement provides for cooperation between the two countries in: (i) the design, development and fabrication of all kinds of satellites; (ii) the provision of satellite launch vehicle services; (iii) the utilization of various applications of space technology; and (iv) the training of personnel. The Agreement came into force for a period of five years, extendable for another three years with the mutual consent of both Parties.

5.4 A Memorandum of Understanding was signed by Pakistan (SUPARCO), China (Ministry of Aerospace Industry) and Thailand (Ministry of Transport and Communication) for holding jointly an Asia-Pacific Workshop on Multilateral Cooperation in Space Technology and Applications in China from 30 November to 5 December 1992. The Workshop is intended to provide a forum for various agencies, institutions, companies and experts involved in space technology and its applications, in order to study and discuss various relevant issues for forging multilateral cooperation among the countries of the Asia and the Pacific region in the disciplines of space technology and its applications.

5.5 The possibility of cooperation between the China Centre for Resources Satellite Data and Application (CRESDA) and SUPARCO in the field of remote sensing and its applications is currently being discussed to explore the areas of mutual interest in that field.

5.6 Following a world-wide call from the National Space Development Agency (NASDA) of Japan, SUPARCO's scientific proposal entitled "Investigations for Ancient River Channels as possible Sources of Groundwater in the Cholistan Desert" has been selected by NASDA for inclusion in its JERS-1 Verification Programme.

6. International/regional organizations

6.1 The United Nations Committee on the Peaceful Uses of Outer Space, along with its two subcommittees, has been playing an extremely useful role in international space affairs by way of providing a forum to exchange views and to discuss developments, issues and matters relating to the outer space activities of Member States. The Legal Subcommittee is instrumental in drawing up a body of space law governing the peaceful exploration and utilization of outer space. The Scientific and Technical Subcommittee is involved in promoting international cooperation on space projects.

6.2 As a member of the Committee on the Peaceful Uses of Outer Space, Pakistan has regularly participated in the annual sessions of the main committee and its subcommittees. Pakistan has been making a regular voluntary contribution during the past several years in support of the United Nations Space Applications Programme and has made a cash contribution of US$ 15,000 for the year 1992.

6.3 SUPARCO is also an adhering member of the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU). In this capacity, SUPARCO participated in the COSPAR biennial plenary meetings and associated symposia, workshops etc.

6.4 The International Astronautical Federation is an association of several space agencies and space-related firms. Pakistan is a voting member of IAF.

6.5 Pakistan is also a State member of the Economic and Social Commission for Asia and the Pacific. As Pakistan's national space agency, SUPARCO has been actively participating in the United Nations Development Programme (UNDP)/ESCAP Regional Remote Sensing Programme for the development of remote-sensing capabilities in the ESCAP region. Senior SUPARCO scientists have also been attending the meetings of the Directors of the Remote Sensing Centre/programmes of the countries of the Intergovernmental Consultative Committee of RRSP. SUPARCO also functions as the national contact point in Pakistan for education and training and for the Regional Information Service of RRSP.

6.6 SUPARCO-ESCAP/UNDP organized jointly a Regional Seminar on the Applications of Remote Sensing Techniques to Land-use Planning and Environmental Surveying at Karachi from 21 to 27 October 1991. It was attended by 56 participants and observers from 16 countries and international agencies. Ten presentations were made from the SUPARCO side on a wide range of topics relating to the theme of the Seminar.

6.7 As a member of the South Asian Association for Regional Cooperation (SAARC), Pakistan participates in the meetings of the SAARC Scientific and Technical Committee for promoting cooperation among the members of the Association in various fields of science and technology, including remote sensing.

6.8 Pakistan is also represented in the World Meteorological Organization (WMO), the International Telecommunication Satellite Organization (INTELSAT), the International Maritime Satellite Organization (INMARSAT), the World Conservation Union (IUCN) and the Asian Association of Remote Sensing (AARS).

6.9 The Government of Pakistan authorized SUPARCO in July 1991 to sign, as a ground segment provider, the Notification of Association with the International COSPAS-SARSAT Programme.

6.10 Under auspices of the United Nations Department of Technical Cooperation for Development SUPARCO and the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) will be jointly carrying out a project entitled "Application of Remote Sensing to Coastal Zone Monitoring". In this connection, two scientists of SUPARCO will be visiting Bangladesh during 1992 to provide consultancy service to SPARRSO for working out the modalities for the execution of the project with the Bangladesh counterpart officials.

6.11 In response to a proposal from the United Nations Office for Outer Space Affairs, Pakistan has offered to host the United Nations Regional Centre for Space Science and Technology Education for the Asia and the Pacific Region.

6.12 A decision to establish an Inter-Islamic Network on Space Sciences and Technology (ISNET) was taken in January 1987. Later in that year, the founding meeting of the Network on Space Sciences and Technology was hosted by SUPARCO in Karachi. It was decided at that meeting that the Network Office would be located in Pakistan, for which SUPARCO had agreed to provide the necessary facilities. A detailed report on the progress made by ISNET was submitted for presentation at the OIC Summit held at Dakar, Senegal, as well as at the COMSTECH General Assembly meeting at Islamabad. The ISNET report was also presented at the fifth COMSTECH General Assembly meeting by the Executive Director of ISNET.

7. Activities considered suitable for greater international cooperation

7.1 The space activities which should be the subject of greater international cooperation, keeping in view the needs of the developing countries, should include:

(a) Technical cooperation for the transfer of technology, mutual exchange of experts and provision of consultancy services and training opportunities in the following areas:

(i) Remote-sensing applications to Earth resources survey and environmental studies (training of personnel in various disciplines of remote-sensing technology and applications, sensors development, aerial remote sensing, software, etc.);

(ii) Operation, maintenance and licensing of remote-sensing satellites, ground stations and coordination in the remote-sensing space segment;

(iii) Development of satellites and their launching, interface with terrestrial communication infrastructure, software and hardware aspects of DBS, free or subsidized availability of television/telephone transponders on satellites for the promotion of education, health care and communications, particularly in rural areas of developing countries;

(iv) Space meteorology (development of data-processing software, meteorological sensor development, establishment of high-resolution picture transmission (HRPT) stations for data reception and processing, fabrication of data-collection platforms, training of personnel in the area relating to space meteorology;

(b) Provision of assistance to the developing countries in the form of consultations for rendering advice in the preparation of project proposals, installation, commissioning and maintenance of the equipment and making available the satellite transponders for communication and television broadcast services on a long-term basis;

(c) Establishment of a centralized databank accessible through computer terminals, and provision of improved information exchange service in the form of physical exchange of technical documentation;

(d) Holding of joint meetings of space scientists and technologists of the developing and developed countries in order to facilitate the process of implementation of space science- and space technology-related projects in developing countries;

(e) Encouraging the extensive cooperation among countries within a region through sharing their resources of manpower, technical know-how, hardware and software for the projects falling in the application areas mentioned in subparagraph (a) above. The Regional Remote Sensing Programme, a project of UNDP and ESCAP is an excellent example of that;

(f) Sharing of experience by the technologically developed countries with the developing countries in various fields relating to space technology and space sciences (examples: design and development of low-cost satellite systems for communication; remote-sensing and meteorological applications; development of satellite launching capability; designing of hardware for scientific experiments on board a spacecraft, etc.);

(g) Provision of launch services, on reduced rates, by the developed countries for the satellites developed by the developing countries;

(h) Placement of scientists/engineers of the developing countries in the establishments located in the developed countries engaged in space technology-related activities, for their hands-on experience;

(i) Accommodating scientific experiments designed by the developing countries involved in space research activities, in the spacecraft operated by the developed countries;

(j) Wide dissemination of scientific/technical information relating to the spin-off benefits emanating from the activities of the space-faring nations in outer space and assisting developing countries in their useful applications.

7.2 Pakistan has already announced training opportunities for the scientists/engineers of the developing countries in the following fields:

(i) Ionospheric studies;

(ii) Remote-sensing applications for Earth resources and environmental surveying;

(iii) Design and development of ground terminals for reception of signals from direct TV broadcasting satellites.

8. Spin-off benefits of space activities

8.1 At present, the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), the national space agency, has not utilized so far the spin-off benefits of space activities. However, it maintains interest in developments in this field and would like the developed countries which are actively engaged in this area to share their experiences with the developing countries.

POLAND

[Original: English]

The Committee on Space Research of the Polish Academy of Sciences coordinates the activity of a number of institutions in Poland in the field of space research and applications. This activity is connected to international programmes and bilateral agreements between Poland and other countries. The agreement with the European Space Agency (ESA) was approved by both sides at the end of the current year.

The present report presents some results of space activity in Poland in the field of space physics, remote sensing, satellite geodesy, space telecommunications and space biology and medicine.

Space physics

Polish activities in the field of space physics are noticeable in various directions, starting from the Earth ionosphere and ending on gamma-astronomy. They were concentrated on:

- Participation in space missions;
- Design and construction of scientific equipment for experiments in space physics;
- Processing and interpretation of data obtained from space experiments;
- Theoretical approach to topics related to space physics.

Space missions

Currently Poland participates in two international space projects in orbit: APEX and GAMMA-1.

The aim of the APEX project (two statellites launched on 16 December 1991) is to study the ionospheric plasma and its interactions with beams of high-energy electrons. There are six instruments, designed and constructed in Poland, aimed at measuring spectral features of plasma waves, stimulated in the ionosphere. Current data analysis reveals that all of them work satisfactorily.

GAMMA-1 (launched on 11 July 1990), aimed at the study of cosmic gamma-radiation, is the second current international space mission with a Polish contribution in instrumentation. Here the stellar sensor, Telestar, for the determination of satellite attitude, has been developed and provided by Poland.

Construction of hardware for future experiments

The development of Polish instruments for several international projects in space physics is currently under way. Most of these projects are coordinated by the Space Research Institute in Moscow and one by NASA.

Below is the list of instruments which contribute to the international space projects:

- Spectrum analysers for waves at radio frequencies for ionospheric and magnetospheric studies; projects: a Nasa rocket, INTERBALL and MARS-94;
- Solar X-ray photometers and spectrometers for INTERBALL. CORONAS-I and CORONAS-F;

- A detector of high-energy neutral particles scheduled for a RELICT-2 mission;

- An infrared planetary Fourier Spectrometer for the MARS-94 mission.

Data processing and interpretation

The data obtained from a variety of satellites have been processed in Poland and used for interpretation by Polish space physicists. They are listed below:

- Processing and interpretation of data from the AKTIVNY and APEX missions;

- Measurements and analysis of scintillations of radio signals from the Polar Bear satellite on the Polish Polar Station - Spitzbergen;

- Analysis of plasma waves based on data from the Prognoz-8 and Ampte-Uks spacecraft;

- One scientist from Poland had participated in data interpretation from a plasma-wave instrument while he was a member of the Voyager 2 team during the encounter with Neptune;

- Usage of data from the Vega-2 mission for studies of dust particles around the comet;

- Usage of X-ray data from the Solar Maximum Mission for investigation of flare heating, plasma motions in flares and chemical composition of flare plasma;

- Usage of Einstein observations for reconstruction of the stellar corona of the AR Lacertae binary system;

- Interpretation of 2-3 kHz VLF emissions recorded by the Voyager-1 and Voyager-2 spacecraft;

- Studies of interstellar extinction based on TD-1 and ANS satellite ultraviolet data;

- Studies of pulsating stars based on data from the IUE satellite;

- Contribution to observational results from the Gamma-1 satellite.

Theoretical approach to topics related to space physics

Here work has been concentrated on solving problems concerning widely understood terrestrial environment, viz., the ionosphere, magnetosphere, heliosphere, solar flares and even variable stars. Below are listed areas in which theoretical work has been carried out:

- In magnetosphereic research: modelling of the Earth's magnetosphere and magnetotails of the planets;

- In heliophysics: modelling of flares;

- In heliospheric research: studies of interactions of neutral particles with interplanetary plasma and dynamics of interaction of solar wind with the local interplanetary plasma;

- In astrodynamics: studies of non-gravitational motions in the solar system and studies of rotational dynamics of orbiting bodies;

- In astrophysics: model calculations of pulsating stars.

Centres of activity in space physics

The majority of the space activities in Poland is concentrated in the Space Research Centre in Warsaw. Most of the contributions to the present report originate from there. The Solar Physics Division of the Space Research Centre in Wroclaw is very active in space-related heliophysics. The spacecraft-oriented interpretations of ultraviolet observations are carried out at the Astronomical Institute of Wroclaw University and the Astronomical Institute of Nicolaus Copernicus University of Torun. Theoretical studies of the rotational dynamics are continued at the latter institute. Also in Torun, at the Laboratory of Astrophysics of the Copernicus Astronomical Centre, work on the experimental studies of the magnetospheric radio emissions is being conducted.

Satellite geodesy

Activity of the geodynamic station Borowiec was focused on observations of the Lageos satellite. In the period 1990-1991 the following observations were performed:

Satellite:	Starlette	Ajisai	Lageos	ERS-1
No. returns:	4 561	19 924	14 116	365
No. passes:	31	72	102	6

In September 1991, a new laser transmitter was installed. The following parameters have been achieved:

- Pulse energy (green light) - 100 mJ;

- Repetition rate - 10 pulses/sec;

- Pulse length - 100 pico sec.

Observations performed at the end of 1991 confirmed the predicted accuracy to a level of 3-4 cm.

The laser observations were carried out in the framework of international programmes such as the NASA Crustal Dynamics Project, the Wegener Medlas Project and polar motion determinations.

Utilization of the GPS technique for geodynamic determinations

Baltic Sea Level Project - the first GPS campaign

The Baltic Sea Level Project was proposed in 1989 for the study of sealevel changes, land uplift investigation and connection of levelling networks of the countries surrounding the Baltic Sea. Different kinds of measurements are proposed but the crucial ones are GPS measurements of the tide gauges. In October 1990 a two-week GPS campaign was performed in which scientists from eight countries were involved. The operation was very successful. Thirty tide gauges were connected to the network of fiducial points, being SLR and/or VLBI stations.

Scientific goals of the Baltic Sea Level Project

The Baltic Sea Level Project is based on the recommendations published by the Committee on Geodetic Control for Tide Gauges. These recommendations underscore the importance of the GPS technique for the geodetic fixing of the tide gauges. However, GPS should be applied for the connections of the tide gauge stations to the reference stations with well-established geocentric position by the VLBI or SLR method. Taking into account the above constraints, the scientific goals of the Baltic Sea Level Project are formulated as follows:

(1) Unification of vertical data and their time variability for the countries around the Baltic Sea;

(2) Contribution to determination of the gravity field and geoid in the Baltic Sea area;

(3) Determination of mean sealevel and sea surface topography of the Baltic Sea using altimetry, gravimetry and GPS data;

(4) Study of the effect of the sea floor topography;

(5) Monitoring the postglacial rebound of the Earth's crust, especially in the sea area;

(6) Remeasurements of the Baltic Ring for horizontal deformations study using GPS.

The network consists of two categories of points: reference points and tide-gauge benchmarks. Fortunately, in our part of Europe we have a sufficient number of SLR and VLBI stations with well-established geocentric coordinates.

October 1990 GPS campaign. The observation campaign was performed in October 1990. The organization was discussed during the meeting held at Canada, on 6 September 1990. It was decided that the fiducial points would be occupied for 12 days and the tide gauge stations for 6 days at least. Because of the long distances from Metsahovi and Onsala to the Tromso reference stations, two additional supporting stations were planned at Martsbo and Visby, Sweden.

Preliminary results. The data gathering took a long time. Some data files reached the data centre only in July 1991; therefore a full analysis of the campaign was impossible. However, some limited subnetworks were calculated. Some preliminary results have been presented by the Finnish Geodetic Institute, the Space Research Centre, Warsaw, and the Royal Institute of Technology, Stockholm.

Geodynamic Profiles in Central and Southern Poland

The project Geodynamical Profiles in Central and Southern Poland (SAGET) was initiated and worked out in the Institute of Geodesy and Geodetical Astronomy of the Warsaw University of Technology. Its purposes are the establishment and measurements of traverses that form a multifunctional satellite-geodetic network covering the territory, of Central and Southern Poland. The work related to the project is planned for several years. Periodically repeated satellite, astronomic, geodetic and gravimetric measurements made along geodynamical profiles enable the undertaking of complex geodynamic investigation using satellite and modern geodetic techniques. The multifunctional character of the established network of traverses will make it useful for geodynamic investigations as well as for the investigations of the deep tectonic structures; it will also form the country's necessary test field, where all the modern satellite and geodetic techniques and technologies could be investigated and tested.

The programme of work for 1990-1991 included the establishment of the first sections of the geodynamic traverse and GPS and Doppler measurements.

The measurements along the SAGET traverses performed so far have been used in some practical analyses. First, the geoidal heights have been calculated along a 165-km traverse crossing the border of two geotectonic platforms. For the calculation several methods were used. The results obtained indicate rather good compatibility of all applied methods and could be used for interesting analyses concerning their accuracy and economical efficiency. Another practical analysis was made by comparison of satellite (DOPPLER and GPS) derived SAGET point positions with those obtained from the national geodetic network. The results indicate some systematic errors of the scale.

Remote sensing

The following review gives short accounts of the use of remote-sensing methods in such branches of applied research and public service as: agriculture, forestry and water management; land use, urban and regional studies; geology and satellite meteorology.

The review is followed by more detailed descriptions of two basic research projects whose purpose is to study the Earth's atmosphere by spectroscopic methods in the infrared and visible spectral range.

Remote sensing in forestry

Research work on assessment of forest quality in endangered ecosystems has been carried out at Opolis since 1991. This work represents the integral part of the international programme, sponsored by the Commission of the European Communities (CEC) and the Food and Agriculture Organization of the United Nations (FAO). Aimed at evaluating the usefulness of satellite remote sensing for monitoring forests on a regional scale. This programme includes studies of translocations of air pollution, conducted by 30 European countries.

The work planned within the project assumes the synergistic use of conventional methods (ground assessment, statistical charts) and the remote-sensing based approach. The main aim of the work carried out is to prepare the method which would integrate remote-sensing data with the results of forest damage assessment, which are currently collected in Europe within different projects. The specific tasks of the project are:

- To map distribution and degree of forest damage;
- To characterize quantitatively areal changes of forests and the degree of their damage within a 20-year period (1972-1992);
- To prepare remote-sensing based methods for monitoring of forests and early detection of forest damage;
- To find the relation between the results of forest damage assessment obtained from ground observations and from satellite data;
- To find threshold values for the loss of needles, which could be detected with the use of satellite data.

In 1991 the first stage of satellite image processing was done, i.e., histogram analysis, band correlations and channel weighting. Radiometric correction of images and supervised classification, based on ground information collected from test sites, was also performed.

Remote sensing in agriculture

Opolis carried on work, sponsored by FAO and the Polish Academy of Sciences, aiming at the assessment of crop yield with the use of NOAA satellite data and meteorological data measured at standard metstations. On the basis of these data, evapo-transpiration was assessed as a residual from the energy budget equation, while the vegetation index (NDVI) was calculated from visible NOAA bands. Soil moisture for the root zone of the grass was assessed from evapo-transpiration values. Soil moisture and NDVI values were indicators for leaf area index (LAI) and biomass assessments. Final yield of forage was determined with the use of model, incorporating LAI estimates. The accuracy of yield assessment using NOAA data was 90 per cent; it was determined through comparison with ground estimates.

Remote sensing in water management

The method for estimation of lake water transparency, lake water quality and its tropic state, using MSS and TM Landsat images, has been prepared. The empirical models for relationships between processed satellite images and water transparency, water quality and total phosphorus content were created using results of in-situ measurements, performed for 28 lakes on 8 different dates. The method applied for the correction and calibration of satellite images gives the possibility of using these models for any dates of satellite data collection, with a low error of estimation of water transparency and lake water quality.

Remote sensing in urban studies

In 1991, research work on applying multi-source data for regional environmental monitoring started at Opolis. This work is aimed at the creation of a digital database for the Warsaw area. Three types of information were used for this purpose: satellite images, cartographic materials and statistical data. A landcover/landuse map has been prepared on the basis of high-resolution satellite data, as well as vegetation and temperature maps derived from Landsat images. Next, three other information layers were created from cartographic and statistical materials: a map of agricultural complexes and maps presenting the distribution of pollution in Warsaw. The digital data bank formed in such a way is the basis for the analysis of the quality of the environment within highly urbanized areas.

Work on preparing satellite image maps on the basis of high-resolution satellite data was also initiated. As a result of this work, the digital workflow, comprising satellite data merging, geometric transformation and graphic editing, has been prepared. This method allows the production of satellite image maps, which are useful for updating, planning and monitoring purposes.

Remote sensing in land-use mapping

In 1991 work aiming at the use of low-resolution NOAA satellite images for large-area land-use inventory started at the Remote Sensing Centre (Opolis). So far, high-resolution Landsat TM and SPOT data have been applied for this purpose, but due to low costs and the availability of AVHRR NOAA images, this effort has also been undertaken. The ARC/INFO system was used as a tool for assigning land-use classes on these images. Within the 1991 work, the coverage of land-use classes was created through digitizing the land-use map prepared on the basis of Landsat TM images. Next, a satellite NOAA image was imported from the ERDAS image processing system to ARC/INFO, forming four coverages associated with particular NOAA bands. Finally land use coverage was intersected with all NOAA satellite information layers, creating the basis for supervised land-cover classification with low-resolution satellite imagery.

Remote sensing in the study of geosystems

The aim the work carried at the Geography Department of the Warsaw University was to analyse Landsat 1.2 and 3 MSS colour composites of the territory of Poland from the point of view of their suitability for environmental surveys, and in particular for the delineation of geographically homogeneous territorial units on the basis of optical characteristics of the source material.

Photomorphic features of images, such as colour (photo-tone), photostructure and photo-texture have been used as criteria for the delineation of homogeneous territorial units. The above approach permitted the identification, in a logical and objective manner, of 12 photometric units of the first order, 50 photometric units of the second order and 519 photometric units of the third order within the study area which embraced almost the entire territory of the country.

The majority of the delineated units (304 units of the third order located in eastern Poland) have subsequently been analysed from the point of view of relations between a satellite image and environmental features depicted on that image.

It has been established that several environmental features (geographical components) are usually jointly responsible for the resultant rendition of the terrain on the satellite image, even though in some cases a single feature can predominantly influence the image characteristics. The latter case has been more often encountered on the images of young, post-glacial landscapes of northern Poland, while the "complex" origin of the photomorphic features of a satellite image has been more frequent towards the mountains in the south of the country.

The following combinations of environmental features have been found to be most frequently responsible for the overall character of the satellite image: (a) geology, relief, soils; (b) geology, soils; (c) geology, relief, first level of groundwater, soils; (d) geology, relief.

The photomorphic units delineated in the course of the present study reflect the influence of specific relations between environmental components on the character of satellite images of the area. These units may be perceived as spatial entities of the nature of geosystems, or natural regions. The borders of the photomorphic units form a network in which individual fields are homogeneous on a satellite image and similar from the point of view of environmental features.

As the first comprehensive analysis and evaluation of satellite images in the Polish literature on the subject, the present study paves the way for further analytical work as well as for synthetic elaborations. The photometric units delineated can also serve in planning a network of satellite-aided environmental monitoring, ecological surveys, change detection, etc.

Remote sensing in geology

A novel method of integrated analysis of multi-thematic data with the aid of computer techniques has been elaborated at the National Institute of Geology. This analysis allowed for finding new geological content of the data, first of all in the field of discontinuous tectonic structures. Information obtained in this way proved very useful in various stages of mineral deposit prospecting. The method served to produce a set of 12 maps in the 1:200,000 scale from a region of southern Poland.

Remote sensing in oceanology

The main achievement of the research carried out at the Division of Sea Remote Sensing and Cartography of Szczecin University is the remote-sensing atlas of the Polish Baltic coast, made with the aid of bathymetric charting.

Remote sensing in satellite meteorology

During the period 1990-1991, studies on the use of satellite data in meteorology at the Institute of Geodesy and Meteorology of the Military Technical Academy comprised three tasks:

(1) Refining upon the methods of determining vertical profiles of temperature, humidity and ozone using TOVS-type multispectral data;

(2) Elaboration of the methods of identifying the thermal state of water reservoirs and their resources;

(3) Confrontation of the real organization and structure of cloudiness and their temporal changes (on satellite images) with results of numerical modelling of atmospheric processes aiming at a better understanding of the nature of these processes.

The first task is a continuation of studies carried in past years and aims at raising the accuracy and reliability in determining the temperature,

humidity and ozone profiles. Accurate determination of the latter concentration is of particular importance since it is connected with the elaboration of reliable algorithms to solve inverse problems which are usually ill formulated, hence hardly manageable by direct numerical treatment.

While carrying out the second task we mainly use infrared images taken in various spectral channels located in the ranges of atmospheric windows. It is especially important here to eliminate the influence which the optical state of the atmosphere exerts on the identification of the state of the ground.

Within the third task the activities were the following: (a) analysis, on satellite images, of phenomena and processes of self-organization of large atmospheric fluctuations expressed in widespread cloudiness systems (fronts, cyclones at moderate latitudes); (b) confrontation of their real position and changes with computer-generated maps of the frontogenesis index, vertical currents and some classical synoptic maps; (c) search, on the basis of satellite images, for connections between self-organizing structures at various scales. Especially valuable are preliminary results related to the influence of organized macro-scale systems (the polar front and widespread cyclones) on the self-organization of meso-scale systems (of the order of several hundred km), which in turn exert a direct influence upon the formation of local weather.

Such a synergistically based procedure is justified for processes occurring in the atmosphere. This is because the latter constitutes an open, balanced thermodynamic system far from equilibrium, hence making a system with creative and dissipative energy factors. It is known that in such systems large fluctuations can pass through stages of generation, development and decline. Satellite images together with meteorological maps make a perfect material for these kinds of investigations.

At the Institute of Meteorology and Water Management, the Satellite Data Receiving and Processing Centre conducts research and applications of satellite information for meteorology, hydrology, oceanology, agriculture and environmental protection.

The research problems are concentrated on:

- Optimalization of the algorithm for land surface temperature determination;
- Optimalization of the algorithm for land surface moisture determination;
- Optimalization of the algorithm for NDVI determination;
- Determination of the sea surface temperature for the Baltic Sea;
- Determination of the global irradiation and photosynthetically active radiation over Poland and the Baltic Sea.

The Satellite Data Interpretation Laboratory of the above-mentioned Institute uses digital data from NOAA polar-orbiting satellites to provide a variety of meteorological products such as accurate determinations of surface and cloud-top temperatures and global images of clouds. All meteorological image products are presented with the SysVision image processing system, which was created in the Laboratory in 1991, and using data from NOAA AVHRR. This method will be used in the near future operationally by forecasters and could also be utilized for serving numerical meso-scale prediction models with appropriate initial cloud and precipitation information.

Space telecommunications

The Institute of Telecommunications is engaged in wave propagation research in Earth-space paths. Previously the signal from the 11.5 GHz transponder from the Lutch satellite was measured within the framework of the INTERCOSMOS programme. Actually, what is measured is the signal radiated from the 12.5-GHz beacon of the Olympus satellite in the framework of Opex. The results of the research are applied for availability assessments of Earth-space paths and also for the prediction of wave attenuation due to rain. For this last purpose the rain rate measurements are conducted under the Earth-space path at several sites. The preparations for receiving the beacon signals from the Italsat satellite have been initiated.

At the Institute research work has been carried out concerning the broad aspects of introducing VSAT systems in Poland. Also the basis has been prepared for establishing a new centre of Earth stations on its territory. In particular, the work is being done on the problem of compatibility between new and existing systems operating in the microwave bands.

Space biology and medicine

The activity within the scope of biology and space medicine conducted at a number of research institutes was coordinated by the Institute of Aviation Medicine in Warsaw.

The research concerned space cytophysiology and space physiology, radiobiology and psychology.

Our previous cytophysiological investigations showed that at the rate maintained during 21 days under conditions of weightlessness changes occur in many organs and systems. Particularly pronounced are disturbances in the skeletal muscular system and the nueromuscular junction. The following muscles were subjected to observation: m. quadricips; m. diaphragma and m. soleus. Morphometric ultrastructural analysis revealed degenerative process of the neuromuscular junction.

In the muscle fibres we found atrophy of the myofilaments, accumulation of glycogen grains and lipid droplets and degeneration of mitochondria. The intensity of these changes was dependent on the kind of muscle. They were most pronounced in the soleus muscle, consisting mainly of red fibre.

We also examined the satellite cells of soleus muscle, which play an important role in development processes and in muscle regeneration. Changes were found both in the nucleas and the cytoplasm, suggesting degeneration of the satellite cells in animals kept in conditions of weightlessness.

It should be stressed that in the rats flown on the biosatellites Cosmos 1887 (13 days) and Cosmos (14 days) changes in the myocardial cells appeared. It was found that in the heart muscle weightlessness causes cellular atrophy, degeneration of the mitochondria and accumulation of glycogen. The changes observed seem to indicate metabolic disturbances of the cells in a continuously functioning myocardium.

The character of the changes observed in the heart muscle was very similar to the disturbances in skeletal muscles found in rats kept under conditions of weightlessness or hypokinesis.

Space physiology studies were carried out on the possibility of utilization of the LBPN model for the evaluation of cardiovascular system tolerance under conditions of increased gravitation. The results obtained indicate that the main individual differences in the possibility of compensation of gravitational changes include the rate and quality of charges of the peripheral resistance. The changes were in relation to the time of onset of the subgravitation stimulus in the LBPN test.

A method has been evolved for non-invasive measurements of vascular impedance. Of particular interest are impedance measurements for the determination of the relationships of the longitudinal and peripheral blood-flow resistance. The relationship between the longitudinal resistance and the peripheral resistance determined in the LBNP test showed a high correlation with acceleration tolerance established in the experiments on human centrifuges.

The results obtained may be useful for the determination of the orthostatic efficiency of the cardiovascular system and for the evaluation of the effects of training during long-term weightlessness.

In the field of radiobiology a cycle of studies have been completed in which estimates were made of the results of exposure to ionizing radiation during space flight. Using various types of radiation of differing energy, the relationships were established between cellular effects and quality of radiation in a relatively broad range of LET radiation. The studies showed that greater effectiveness of cellular damage induction by radiation was related to an increased LET value of radiation and was connected with double-strand breaking of DNA. Radiation with LET value about 90 KeV/nm. that is, of relatively low penetrability, was most effective in killing cells.

For the studies on the effects of radiation on living organisms during space flight, a detector was designed for determination of the spectrum of radiation dose as a function of LET. The determination of the spectral distribution of the absorbed dose as a function of linear delivery of LET

energy was accepted as the proper method for the analysis of radiation fields with unknown composition of ionizing particles.

The subject-matter of space psychology concerns:

(1) Psychological methods and techniques for increasing the ability to work under stress;

(2) Methods for the section of operators working under stress;

(3) Methods for the evaluation of the well-being of the astronauts.

Our empirical investigations have demonstrated that the persons characterized by paratelic domination and a positive type of emotionality are better prepared for coping with tasks requiring creative thinking in stressful situations.